Optimization of a Perchlorate Treatment System at the Former NWIRP McGregor

Presented By
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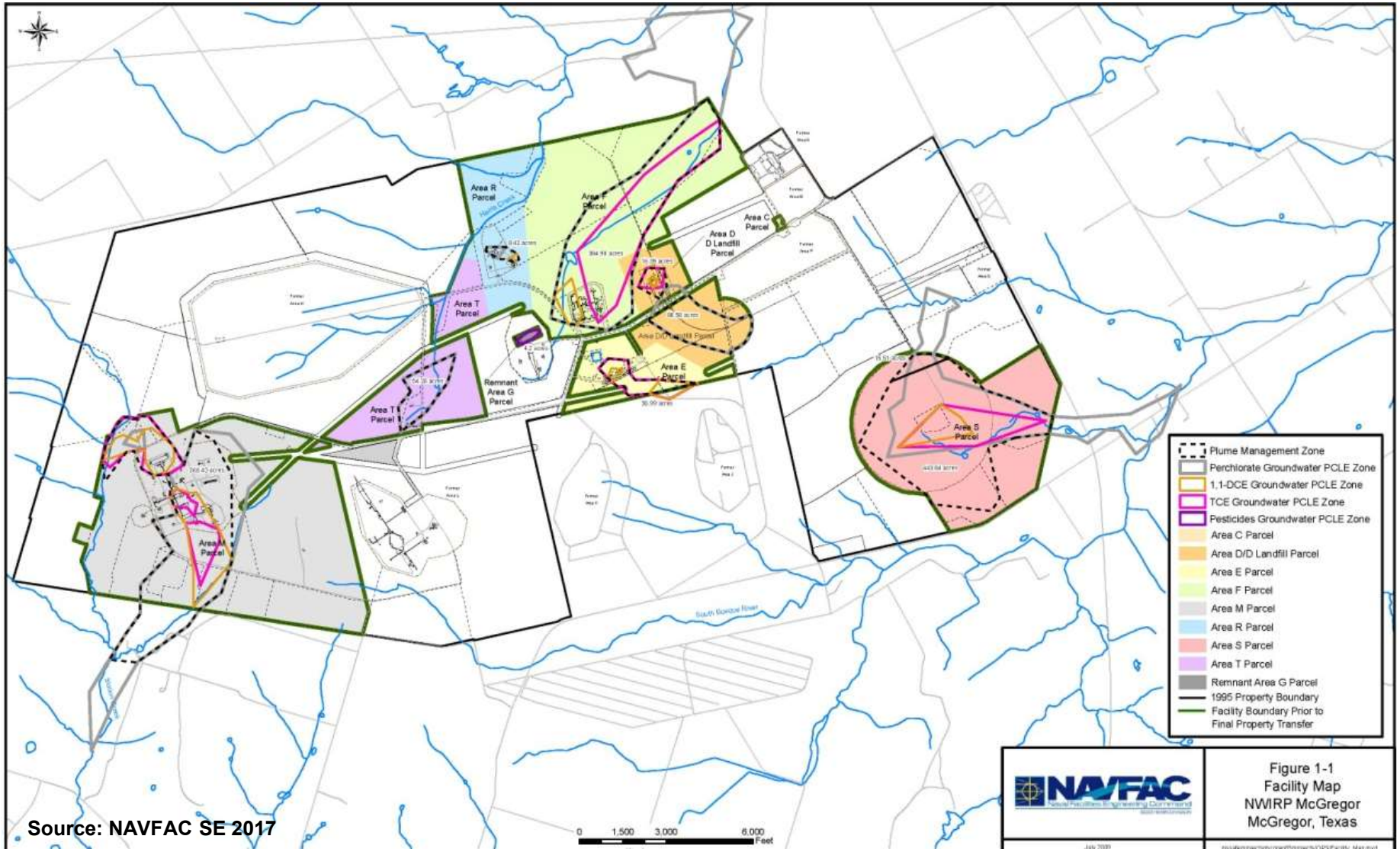
Objectives

- NWIRP McGregor site history and optimization objectives
- Discuss life-cycle optimization using an Adaptive Site Management Approach for a complex perchlorate plume
- Groundwater resource re-classification for installation-wide groundwater
- Describe transition assessment performed to evaluate transition from active pump and treat system to long-term passive treatment
- Ecological assessment to evaluate risks associated with surface water exposure to perchlorate
- Lessons learned and knowledge transfer from long-term optimization of complex groundwater site

NWIRP McGregor Background

- Naval Weapons Industrial Reserve Plant (NWIRP) McGregor used until 1995 as a bomb and rocket motor manufacturing facility
- Isolated industrial sites located on 9,700 acres, 20 miles west of Waco, Texas
- Former government-owned, contractor-operated (GOCO)
- Ammonium perchlorate was released into the environment through “hog out” operations of rocket motors
- Property transferred property to City of McGregor in 1995
- Leased portions of property to industrial and agricultural companies
    - SpaceX static rocket test and launch/landing facility
- Navy maintains cleanup responsibility/liability and continues active remediation and long-term monitoring on properties through access agreements

Former NWIRP McGregor



Source: NAVFAC SE 2017

NWIRP McGregor Area M Remedy

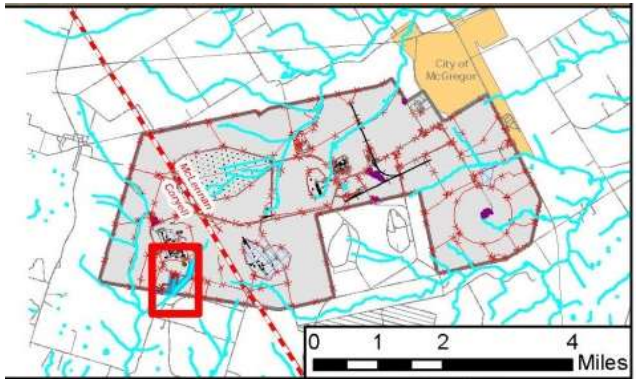
- Navy initiated full-scale groundwater remediation 2002-05
  - Pilot studies for groundwater treatment alternatives and soil excavation and composting 1999-2002
  - Groundwater collection trenches to prevent further off-site migration
  - Fluidized bed reactor (FBR) for effluent treatment
  - In situ bio-barriers for downgradient control of plumes
- Current annual O&M and LTM costs approximately $600,000
- Navy has implemented a life-cycle optimization process since 2004 to ensure remedy remains protective of human health and the environment and cost-effective

Life-Cycle Optimization Timeline

- Initial optimization efforts to improve automation and remote monitoring of FBR operations ***(2004-05)***
- Long-term monitoring program optimization ***(2005–17)***
- Evaluate attenuation capacity of groundwater to surface water pathway ***(2014-15)***
- Re-evaluation of groundwater resource classification with goal of changing groundwater classification from Class II to Class III (raising cleanup level X100) thus reducing the area of regulatory Plume Management Zone (PMZ) ***(2016)***
- Risk evaluation of ecological surface water exposure to perchlorate ***(2016)***
- Transition groundwater collection and FBR system to a series of passive in situ bio-barriers ***(2017-2020)***

NWIRP McGregor

- A-Line Trench – 1,680' long, 20-25' deep
- B-Line Trench – 2,950' long, 12-15' deep
- C-Line Trench - 1,425' long, 15-18' deep
- Trenches initially filled with compost, eventually used for collection only
- Pump Station B maintains groundwater elevation to prevent discharge to unnamed tributary



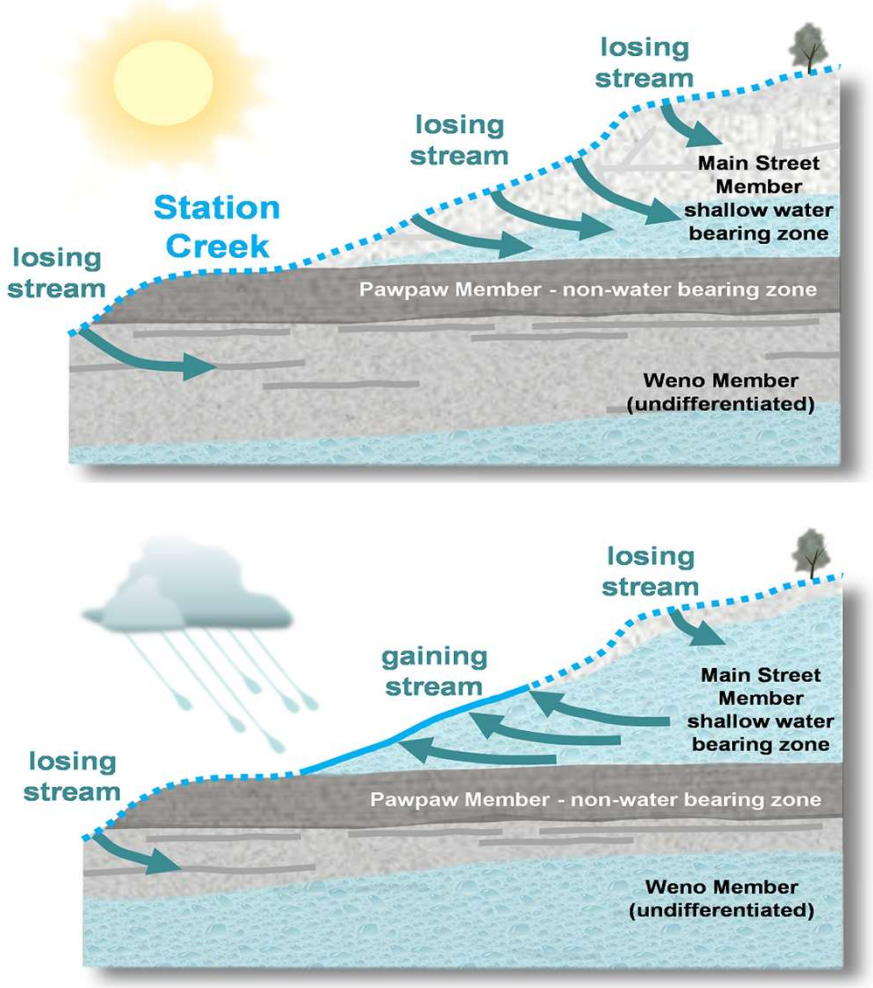
Conceptual Site Model

- Area M industrial operations built on topographic high
- Contaminants (perchlorate and CVOCs) migrate through thin soil cover and into upper water-bearing limestone
- Relatively conservative perchlorate migrated through Station Creek Basin through groundwater/surface water interactions
- Groundwater discharge followed by evaporation, precipitation, re-dissolution, etc.
- Dilution and attenuation occur in this dynamic hydrologic system

Source: NAVFAC SE 2015

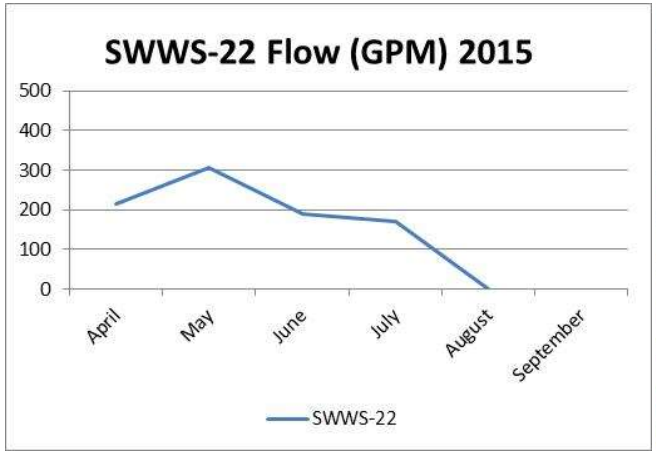
Conceptual Site Model

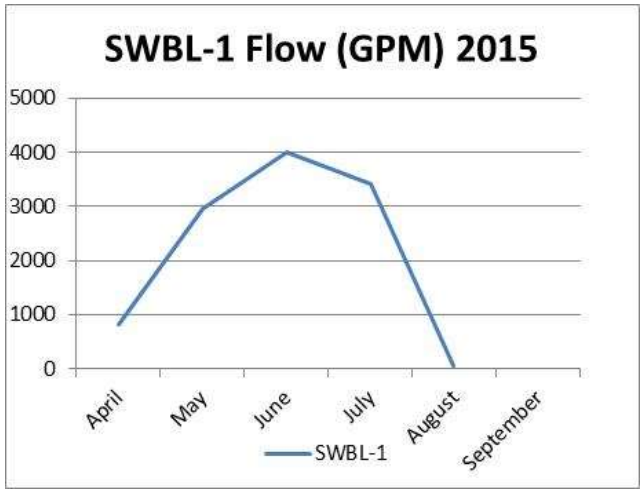
- Streams and tributaries at the facility experience both gaining and losing conditions
- Majority of precipitation occurs in Spring
- Perchlorate effectively attenuated through dilution and mixing within dynamic system
- Dilution study conducted in 2014-15 to evaluate perchlorate concentrations along GW/SW flow path



Source: NAVFAC SE 2017

Variable Surface Water Flow





Source: NAVFAC SE 2015

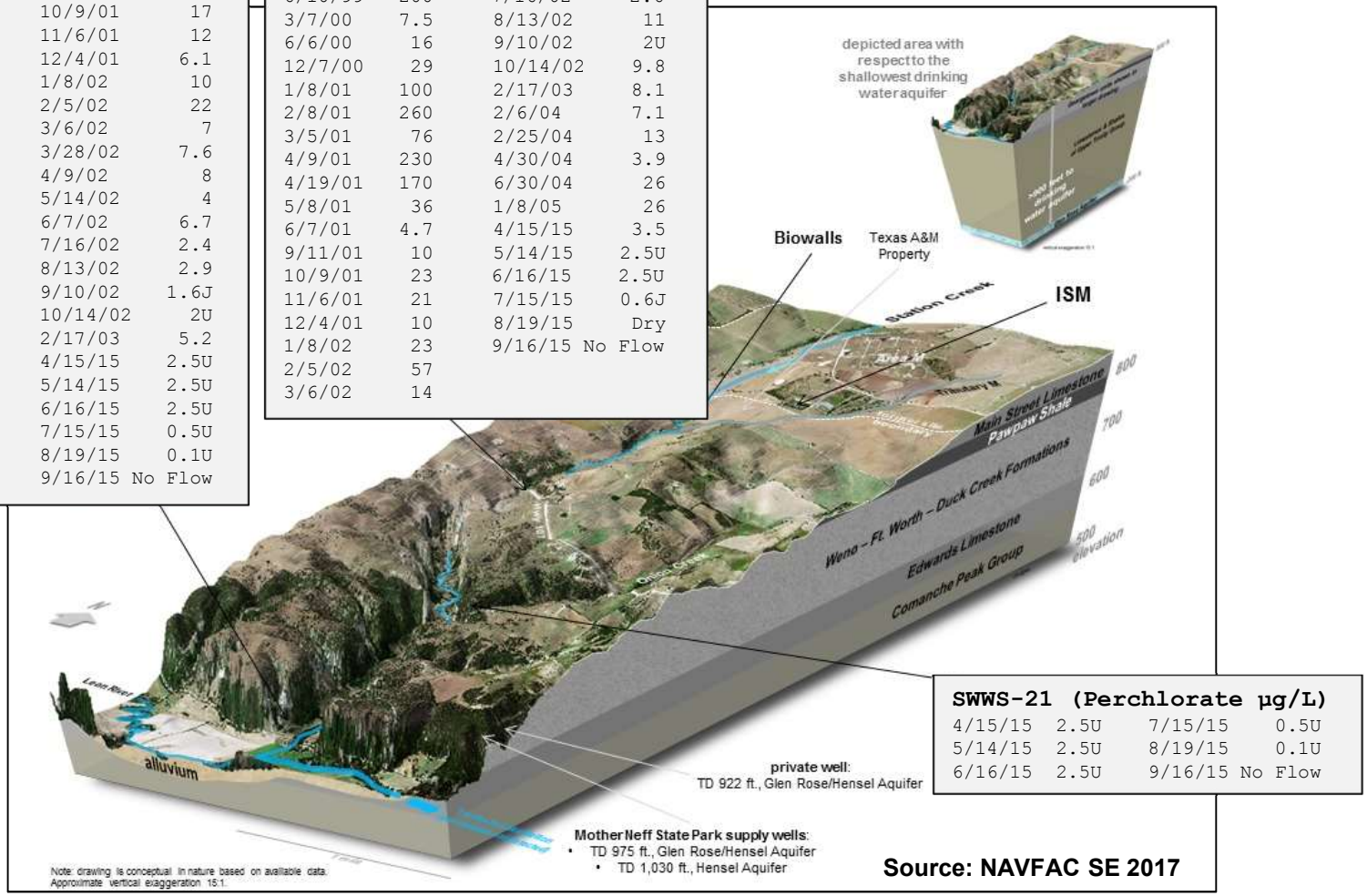
Off-Site Perchlorate in Surface Water

SWBL-1 (Perchlorate µg/L)

2/27/99	160	10/9/01	17
4/8/99	210	11/6/01	12
5/7/99	56	12/4/01	6.1
6/10/99	51	1/8/02	10
7/7/99	55	2/5/02	22
8/11/99	31	3/6/02	7
4/11/00	20U	3/28/02	7.6
5/9/00	17	4/9/02	8
6/6/00	16	5/14/02	4
7/12/00	19	6/7/02	6.7
11/9/00	4U	7/16/02	2.4
12/7/00	11	8/13/02	2.9
1/8/01	46	9/10/02	1.6J
2/8/01	95	10/14/02	2U
3/5/01	30	2/17/03	5.2
4/9/01	120	4/15/15	2.5U
4/19/01	66	5/14/15	2.5U
5/8/01	26	6/16/15	2.5U
6/7/01	20	7/15/15	0.5U
7/10/01	14	8/19/15	0.1U
9/11/01	11	9/16/15	No Flow

SWWS-9 (Perchlorate µg/L)

9/18/98	4U	4/9/02	22
1/11/99	570	5/14/02	16
5/6/99	200	6/6/02	35
6/10/99	200	7/16/02	2.6
3/7/00	7.5	8/13/02	11
6/6/00	16	9/10/02	2U
12/7/00	29	10/14/02	9.8
1/8/01	100	2/17/03	8.1
2/8/01	260	2/6/04	7.1
3/5/01	76	2/25/04	13
4/9/01	230	4/30/04	3.9
4/19/01	170	6/30/04	26
5/8/01	36	1/8/05	26
6/7/01	4.7	4/15/15	3.5
9/11/01	10	5/14/15	2.5U
10/9/01	23	6/16/15	2.5U
11/6/01	21	7/15/15	0.6J
12/4/01	10	8/19/15	Dry
1/8/02	23	9/16/15	No Flow
2/5/02	57		
3/6/02	14		

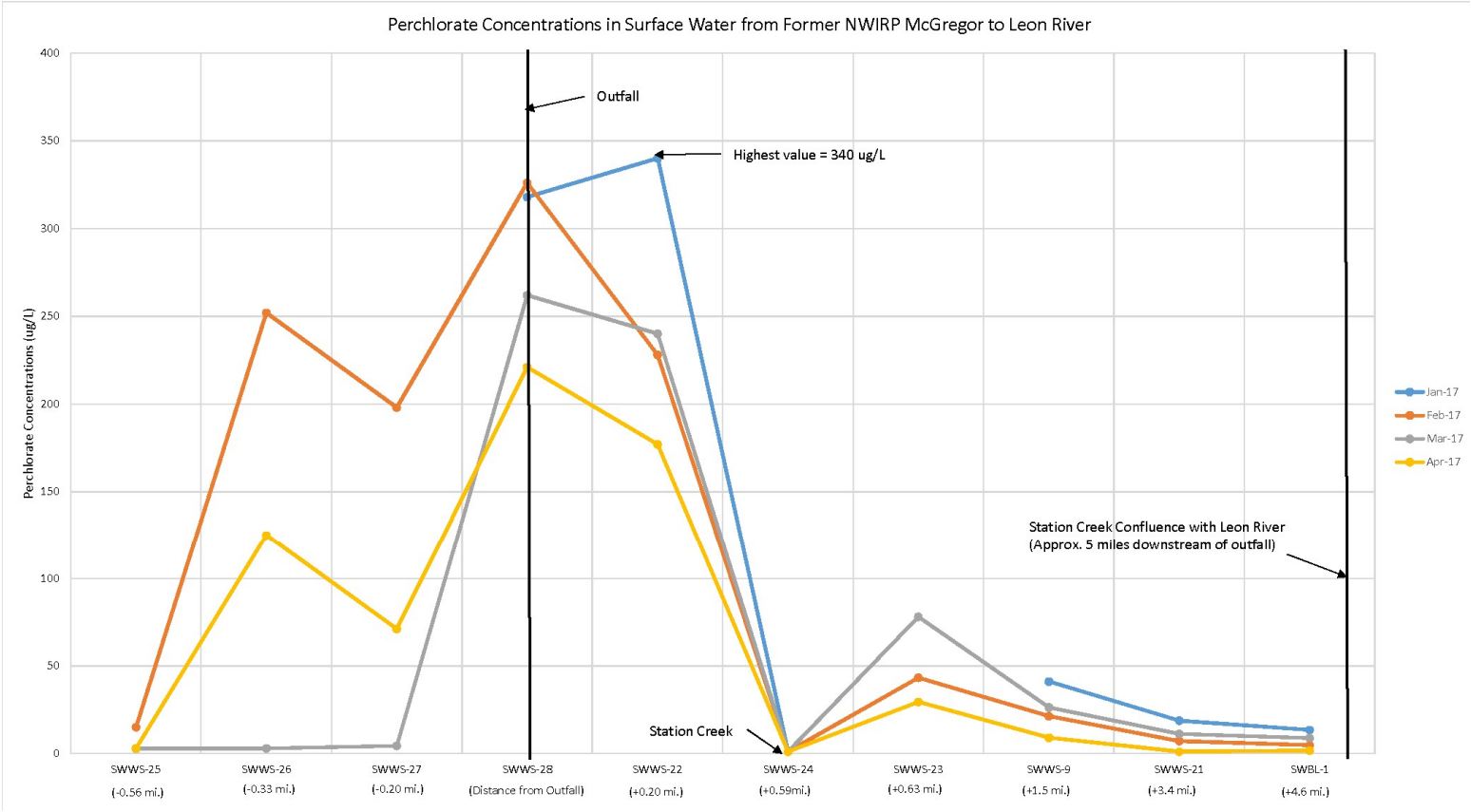


SWWS-21 (Perchlorate µg/L)

4/15/15	2.5U	7/15/15	0.5U
5/14/15	2.5U	8/19/15	0.1U
6/16/15	2.5U	9/16/15	No Flow

Source: NAVFAC SE 2017

2017 Surface Water Data



- **Surface water perchlorate concentrations decrease with increasing distance downstream**
- **Perchlorate less than 20 µg/L prior to reaching confluence of Station Creek and Leon River**

Source: NAVFAC SE 2015

Groundwater Treatment System

Interceptor trench system and aboveground water storage

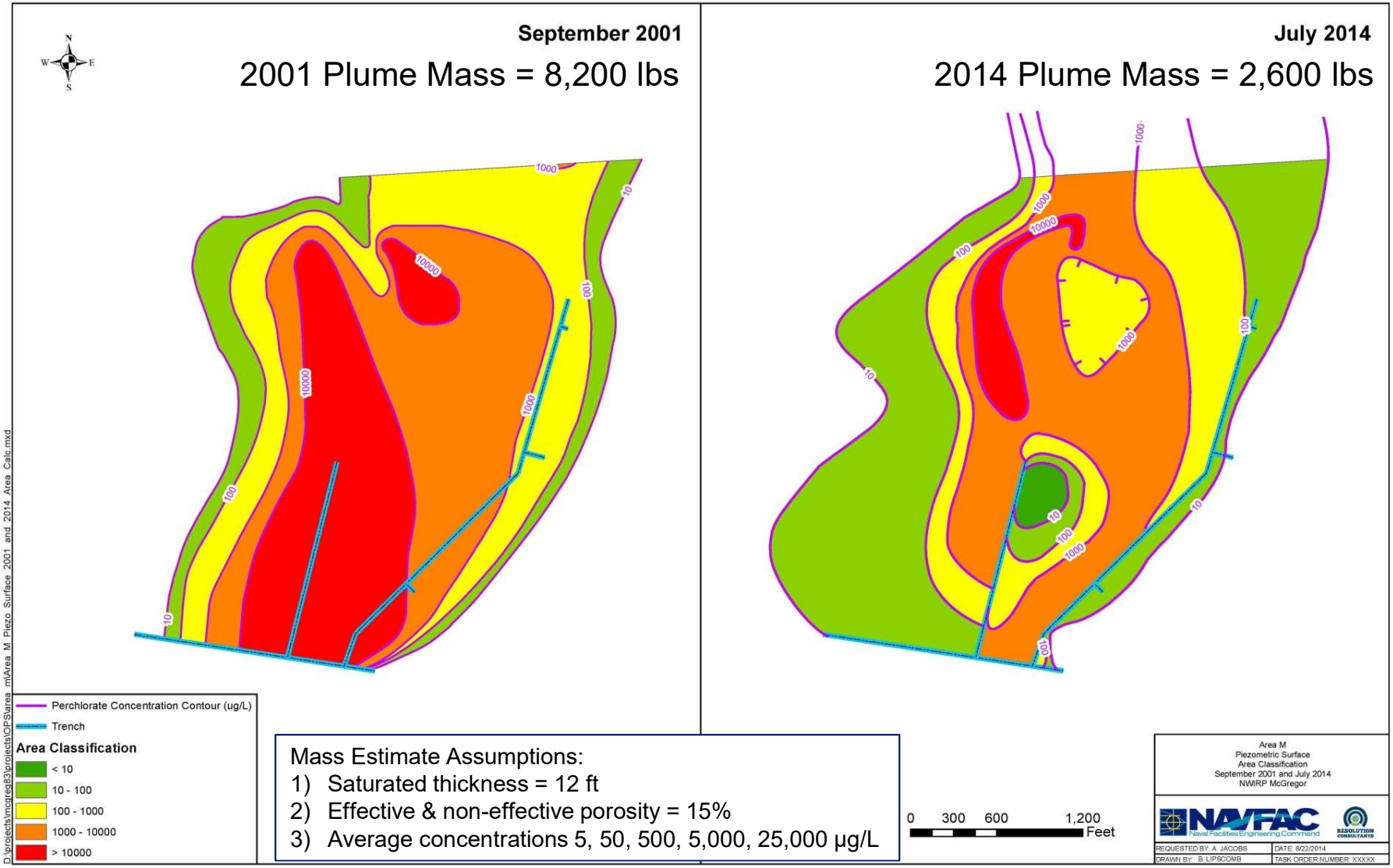
- **Lagoon A – 10.8M Gal**
- **Soil Cell A – 1.2M Gal**
- **Soil Cell B – 1.5M Gal**
- **Soil Cell C – 1.7M Gal**

Fluidized bed reactor

- **Treats up to 400 gpm**
- **Discharges directly to outfall or to aboveground storage**

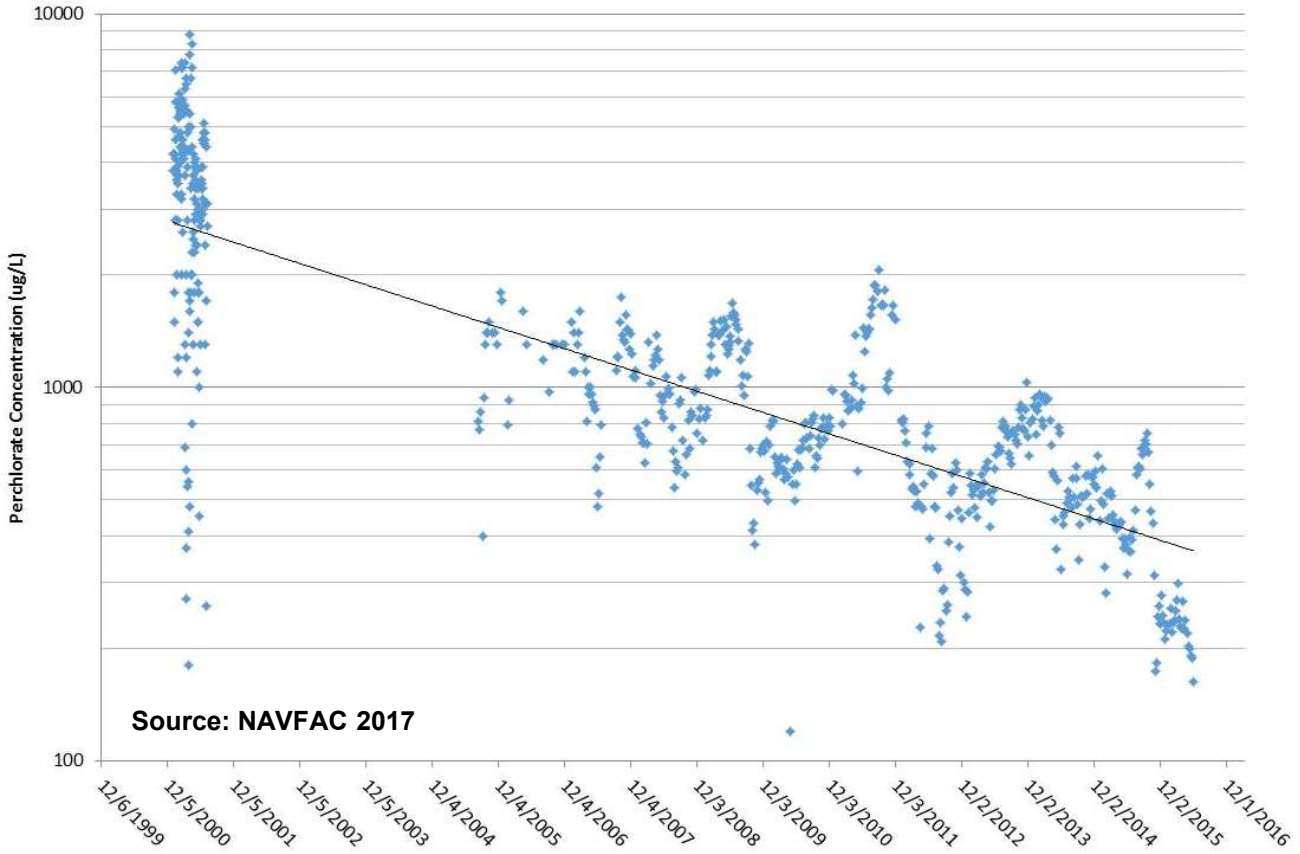
Source: NAVFAC SE 2017

Perchlorate Mass Reduction



Source: NAVFAC SE 2014

Perchlorate Influent History



- **Perchlorate influent concentrations from 2000 to 2016 show overall decreasing concentrations**
- **Combination of source removal, natural flushing, and mixing with un-impacted groundwater resulted in perchlorate attenuation over time**

Transition Assessment

- Goal to transition from aggressive pump and treat technology to passive in situ remediation
  - Reduce O&M, monitoring, and energy costs
  - Rely on in situ containment of the perchlorate plume
- Navy negotiated with TCEQ to temporarily shut down treatment system during 2016-17
- Continue to monitor groundwater and surface water quality in evaluating attenuation capacity
- Pilot test in situ bio-borings to control perchlorate migration from source

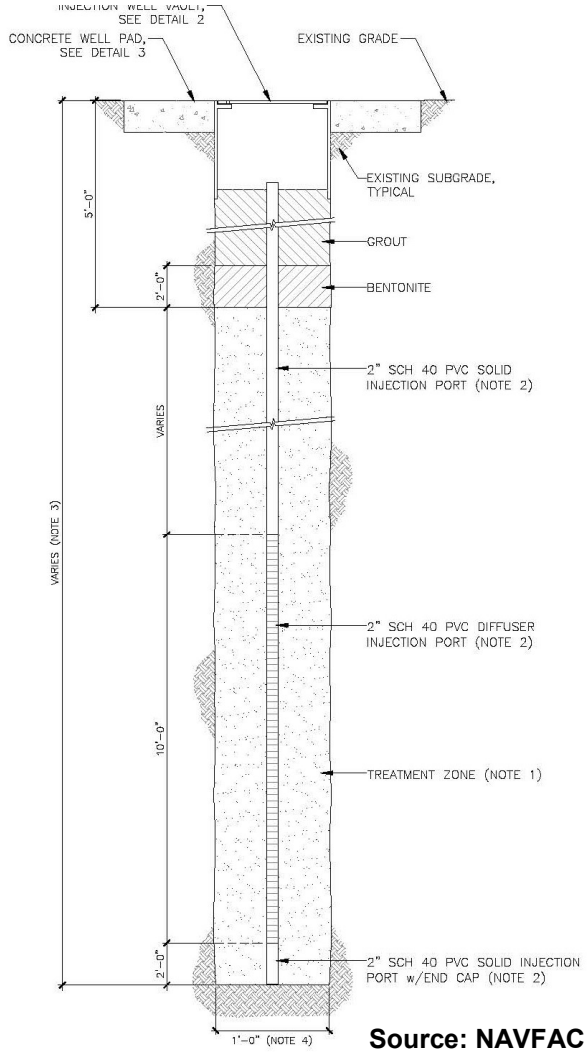
Fluidized Bed Reactor

Source: NAVFAC SE 2017

Bio-Boring Pilot Test

- Series of injection wells installed in August 2016 perpendicular to the groundwater plume
- Installed directly downgradient of remaining source area
- Boring annulus filled with mixture of 60% gravel, 20% compost, and 20% wood chips by volume
- Wood chips and compost saturated with soybean oil prior to installation
- Permanent injection riser for re-application of emulsified oil

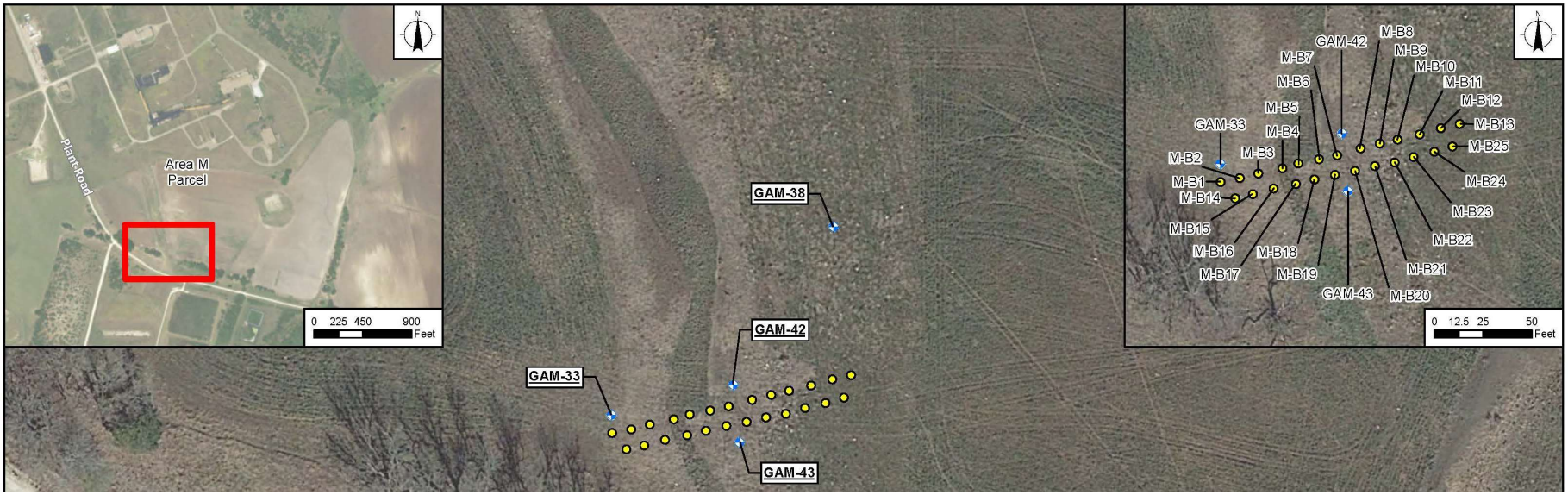
Typical Bio-Boring Injection Well



Source: NAVFAC SE 2017

Bio-Boring Pilot Test

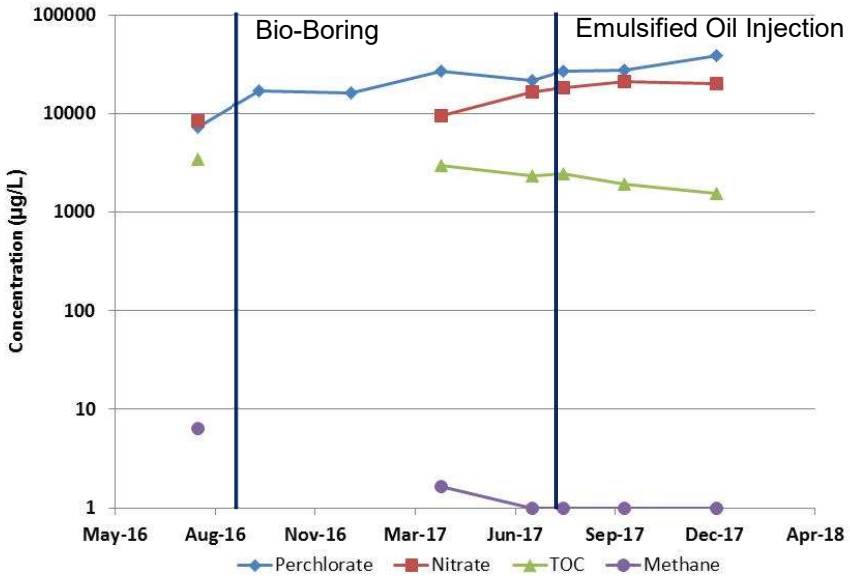
- Two rows of bio-borings installed for a total of 25 wells in August 2016
- Initial compost and wood chip mixture did not provide sufficient reducing power to drive reduction of perchlorate
- Injected emulsified oil in July 2017
- Immediate reductions of perchlorate and nitrate and increase in methane concentrations



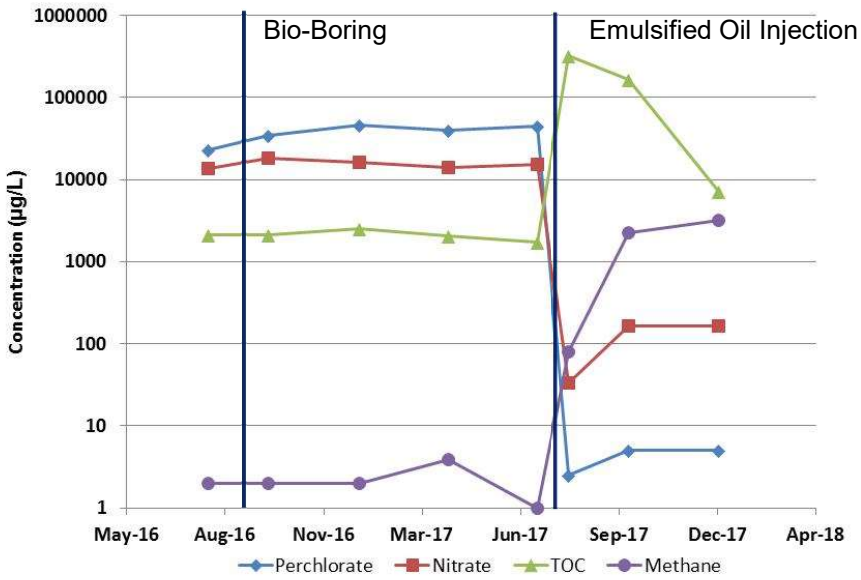
Source: NAVFAC SE 2017

Bio-Boring Performance Monitoring

GAM-42 (Upgradient Well)



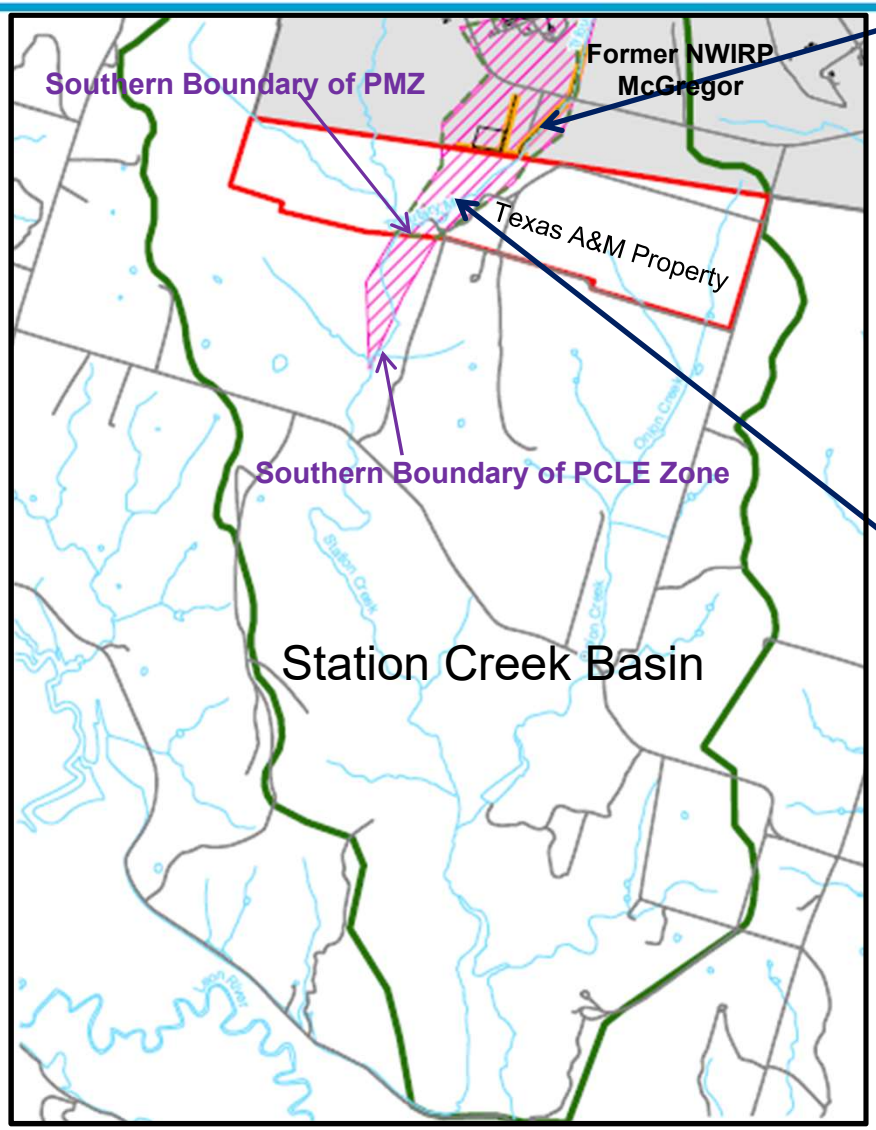
GAM-43 (Downgradient Well)



Source: NAVFAC SE 2017

- **Following injection of emulsified oil, rapid perchlorate and nitrate reduction, methane production**
- **Bio-borings will likely require frequent emulsified oil replenishment to maintain containment of residual perchlorate source**

Groundwater Reclassification



TCEQ's PCLs Onsite Area PMZ		
Medium	Commercial/Industrial (µg/L)	Ecological (µg/L)
Class II Groundwater Classification * TRRP §350.52	51.1	>8,000
Class III Groundwater Classification ** TRRP §350.52	5,110	>8,000
Surface Water	--	>8,000

TCEQ's PCLs Offsite Texas A&M Portion of PMZ		
Medium	Commercial/Industrial (µg/L)	Ecological (µg/L)
Class II Groundwater Classification * TRRP §350.52	51.1	>8,000
Class III Groundwater Classification ** TRRP §350.52	5,110	>8,000
Surface Water	--	>8,000

Source: NAVFAC 2014

Ecological Risk Assessment

- Previous studies indicated that perchlorate-contaminated surface did not impact grazing cattle (USACE 2004)
- Navy conducted ecological studies on sensitive species (amphibians) in 2009 and 2017
- Amphibians (*S. multiplicata*) not sensitive to perchlorate concentrations tested
- Assuming perchlorate concentrations in surface water do not exceed 8 mg/L, unlikely that population levels effects will occur in native amphibians

***S. Multiplicata* at various stages of development**

Source: NAVFAC 2017

Summary

- Life-cycle optimization achieved through a combination of management approaches
  - Groundwater re-classification resulted in less stringent perchlorate cleanup standard (5,100 µg/L vs. 51 µg/L)
  - Developed natural attenuation conceptual model based on site-specific hydrology relying on flushing and mixing in dynamic groundwater/surface water system
  - Transitioning pump and treat system to passive in situ management of plume
  - Successful bio-boring pilot study demonstrating feasible bio-barrier approach to plume cut-off and containment
  - Ecological risk assessment documented no adverse impacts to sensitive receptors from exposure to perchlorate in surface water
- Long-term adaptive site management approach will result in significant annual cost avoidance while maintaining protection of human health and environment

Knowledge Check

- **Was updating the CSM necessary for remedy optimization?**
  - **Better understanding of groundwater/surface water interactions**
  - **Current measurements of downgradient surface water perchlorate concentrations**
  - **More detailed information of residual perchlorate source for bio-barrier design**
- **Can groundwater reclassification help in modifying the remediation approach?**
  - **Increased the perchlorate criteria 100x**
  - **Reduced the size of plume management zones**

Contacts and Questions

Points of Contact
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Questions ?